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Traffic Management by Admission Control in IMS Networks

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Abstract

The paper deals with traffic management in IP multimedia subsystem (IMS) networks. The aim of this article is ensuring quality of service (QoS) in IMS network. Admission control (AC) is used to manage incoming traffic and to prevent the network congestion. The main function of AC is to maximize the utilization of network resources and to ensure the level of QoS. AC was applied on constant bit rate (CBR) and variable bit rate (VBR) traffic. Three methods were chosen for VBR traffic and they were compared. The last part of the article deals with simulations CBR and VBR traffic before and after application of AC.

Keywords: admission control, CBR, IMS, VBR, QoS

1. Introduction

Nowadays, besides using basic services like telephony, SMS, and MMS, it is trend to link voice and data communication. IP multimedia subsystem (IMS) allows combining various multimedia services and access from mobile and fixed devices. Because of that, it seems to be the key element to achieve network convergence. The main advantage of IMS network is a guaranty of quality of service (QoS); this is especially important for real-time applications [1]. Admission control (AC) methods are used for that purpose [2].

2. Admission control

Admission control is a significant process from the point of view of ensuring of QoS [3]. The main function of AC is to estimate capacity for the incoming traffic. Additionally, it has to decide if it is possible to ensure this capacity without any negative impact on QoS of the existing traffic [4–7].

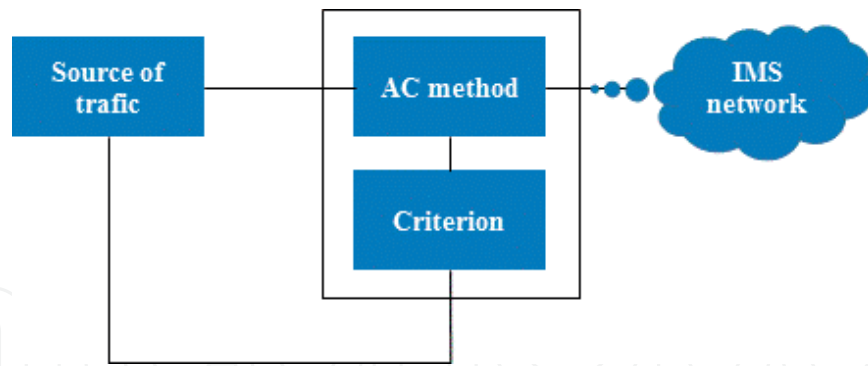


Figure 1. Management of incoming traffic by AC method.

It is a decision-making algorithm. It decides if a new connection is supposed to be allowed or denied within available network resources and guaranteed QoS [8–11].

The way how it works is shown in **Figure 1** [8]. If the new connection with a request of transmitting enters the node, the AC method determines a decisive criterion. The new connection is allowed or denied according to this criterion. The AC methods and specific algorithms are described in the next part. The admission control depends on type of source of traffic.

2.1. Constant bit rate (CBR)

The AC is a simple process in the case of constant bit rate traffic. Every source enters the node with constant bit rate, and it is simple to predict what capacity has to be allocated. Bit rate of every source is constant at the level of peak bit rate during connection. The AC has to keep the following condition:

$$\sum_{i=1}^N p_i + p_{i+1} \leq C, \quad (1)$$

where p_i is peak bit rate of i th connection, p_{i+1} is peak bit rate of new connection, N is number of existing connections, and C is a total capacity of output line, and it will be in all following equations [8].

2.2. Variable bit rate (VBR)

The AC is a complicated process in the case of variable bit rate traffic. The sources can transmit at the level of peak bit rate but also at the lower level. It would be ineffective to allocate the capacity at the level of peak bit rate for all connections. For reaching the maximal utilization of line capacity, the admission control methods, which are described in the next section, are used.

3. Admission control methods

Many admission control methods are known nowadays. They can be divided in general into measurement-based admission control (MBAC) and parameter-based admission control (PBAC). All of these methods are based on the following condition, which has to be respected:

$$P\left[\sum_{i=1}^N r_i(t) \geq C\right] < \varepsilon. \quad (2)$$

Probability that the sum of the immediate bit rate $r_i(t)$ of all N existing connections exceeds the total capacity C has to be lower than the defined bound ε [2, 3, 8, 9].

Good AC methods should keep these conditions:

- Keep QoS of the incoming connection without influencing other connections.
- To react and to decide within a short time to minimize the delay.
- Effectively allocate bandwidth to maximize utilization of the available capacity.

All of these methods should be simply implementable with the possibility of change and maintenance [8, 9].

3.1. Measured sum algorithm

This algorithm belongs among simple measurement-based methods. These methods acquire the necessary parameters by online measurement. The new connection is accepted according to the following condition:

$$C_m + r_{N+1} < \mu C, \quad (3)$$

where C_m is a measured load of the existing traffic; r_{N+1} is bit rate of the new connection; parameter μ expresses utilization of the line capacity from interval $(0, 1)$, in our case it is 0.95 (95%) and C is the total capacity of output line [12, 13].

3.2. Hoeffding bound

As it is mentioned in [12], the main parameter used by this method is the parameter of Hoeffding bound C_H , which is described by this equation:

$$C_H = v + \sqrt{\frac{\ln\left(\frac{1}{\varepsilon}\right) \sum_{i=1}^N (p_i)^2}{2}}, \quad (4)$$

where v is a measured average capacity, which is utilized by the existing connections; p_i is peak bit rate of i th connection; and N is a number of existing connections. According to this parameter, the method decides whether the new connection will be accepted or rejected. The new connection will be accepted according to the following condition:

$$C_H + p_{N+1} \leq \mu C, \quad (5)$$

where parameters μ and C are the same as in Eq. (3).

3.3. Peak rate allocation (PRA)

This method belongs to the group of nonstatistical methods. It is quite simple because it allocates the needed capacity at the level of peak bit rate for every connection. It does not depend on the fact, if the source transmits at the level of the peak bit rate or not.

The decision is made according to this condition:

$$\sum_{i=1}^N p_i + p_{N+1} < \mu C. \quad (6)$$

The new connection is accepted, if the sum of peak bit rates p_i of existing connections along with the peak bit rate of the new connection p_{N+1} is lower than the total capacity of the output line C .

The advantage of this method is that packet loss is very rare. The disadvantage of this method is that if sources do not transmit at the level of peak bit rate, the allocated capacity is not used effectively.

4. Simulations

The simulations were made in software Matlab. The scheme of the network node with AC is shown in **Figure 2**.

Every source represents user equipment. They create requirements using VBR or CBR. Requirements from users represent various data services. Sources are characterized by $M \times N$ matrix, where M is a number of sources and N is bit rates of these sources. The number of sources is 120,

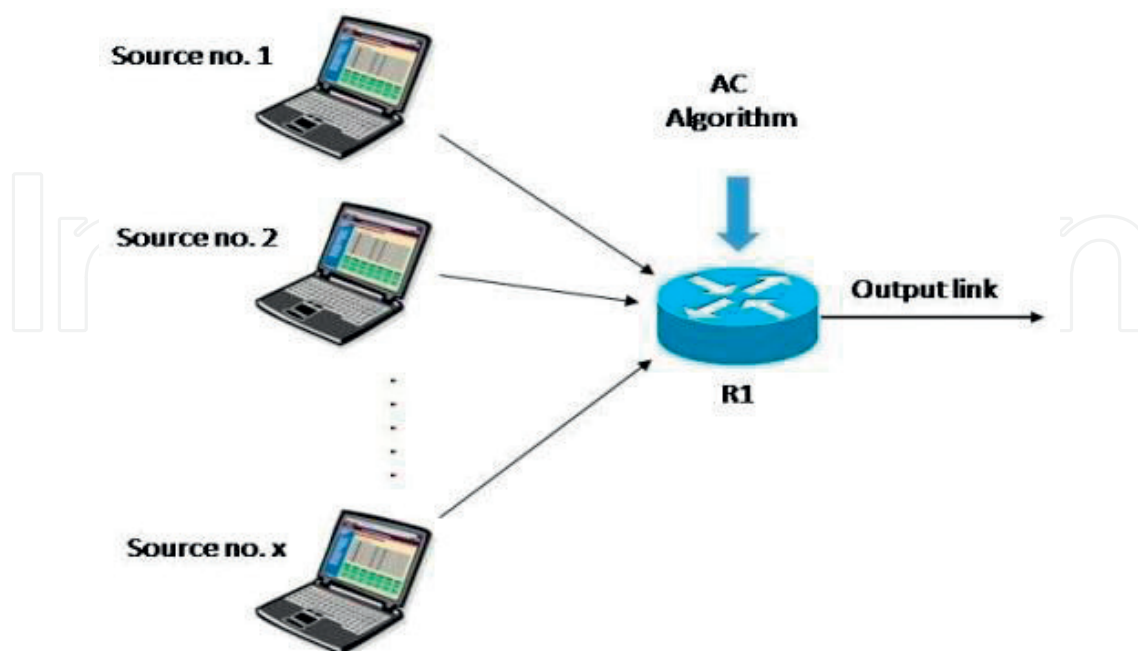


Figure 2. Network topology.

and they are connected to the node (router). There is one common line on its output with the capacity of $25 \text{ Mbit} \cdot \text{s}^{-1}$. We consider the model that one user is connected by every second.

4.1. Constant bit rate (CBR)

In the case of the CBR, bit rates of sources are at the level of $250 \text{ kbit} \cdot \text{s}^{-1}$. **Figure 3** shows when connecting of all sources would be allowed. As we can see, the capacity would be overloaded and QoS would be decreased.

This problem can be solved by using AC. In this case AC is a simple process. If condition (1) is accepted, the capacity will not be overloaded. Expected utilization of line using AC is shown in **Figure 4**.

Expected utilization of output line is under output capacity (red line). Maximum number of accepted connections is 95, and QoS is ensured for every source. This is achieved by admission control.

4.2. Variable bit rate (VBR)

In the case of the VBR, bit rates of sources are randomly generated from the interval from 0 to $512 \text{ kbit} \cdot \text{s}^{-1}$. **Figure 5** shows expected utilization of the line, when all of the sources would be connected. As we can see in **Figure 5**, the capacity would be overloaded. That would cause packet loss or packet sequencing to the queue, and the delay would be increased. QoS of all connections would be negatively affected.

We are trying to prevent situations like that by using AC methods. If the connection of the new source causes a line overload, the connection request will be rejected.

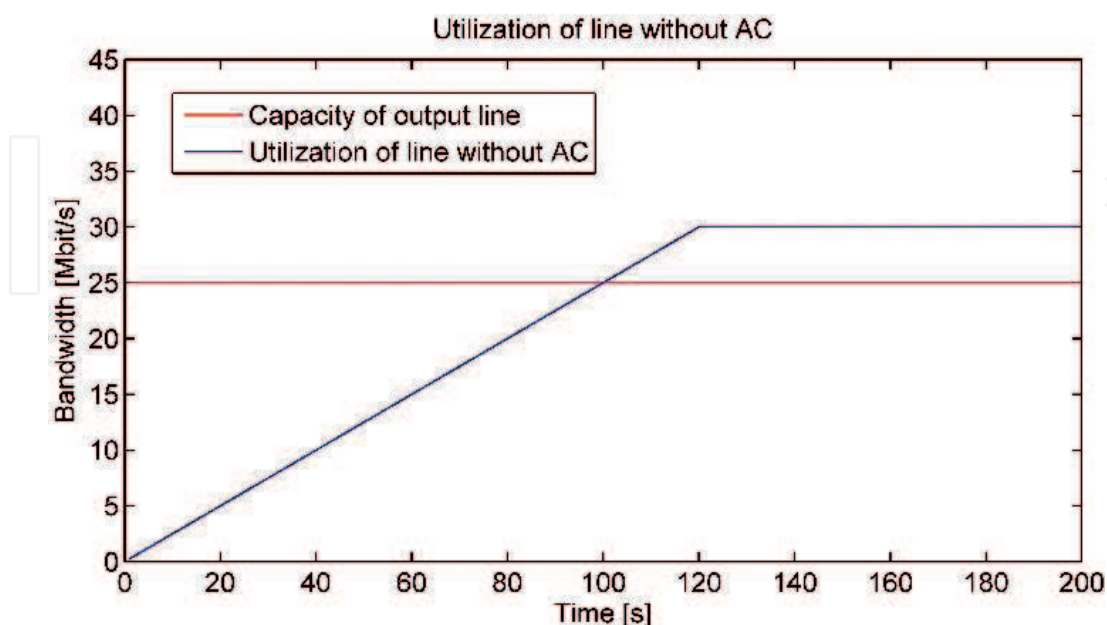


Figure 3. Expected utilization of line, when all sources are connected.

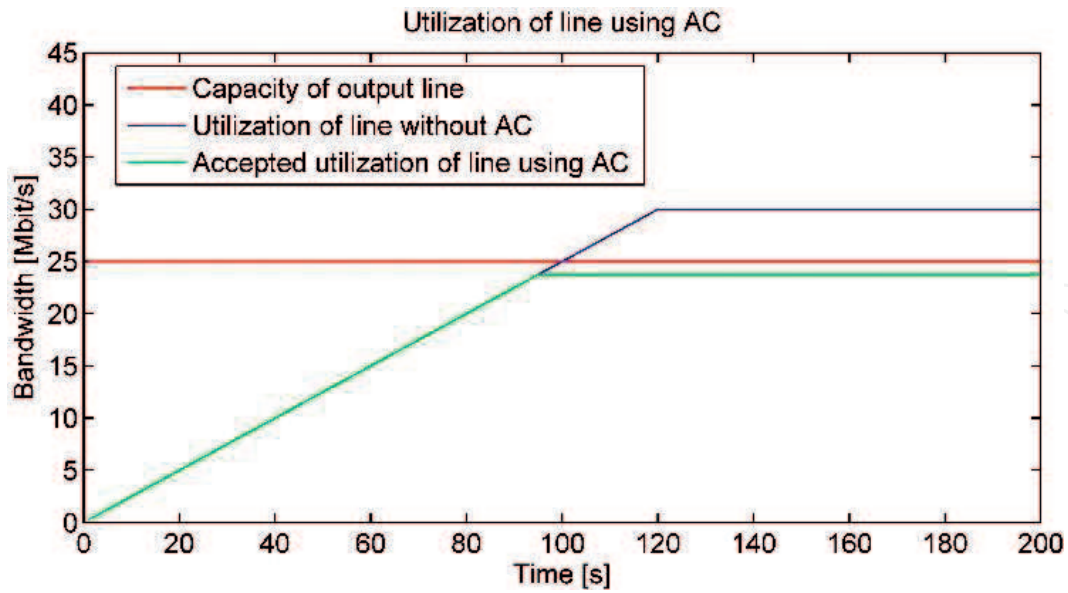


Figure 4. Accepted 95% utilization of line using AC.

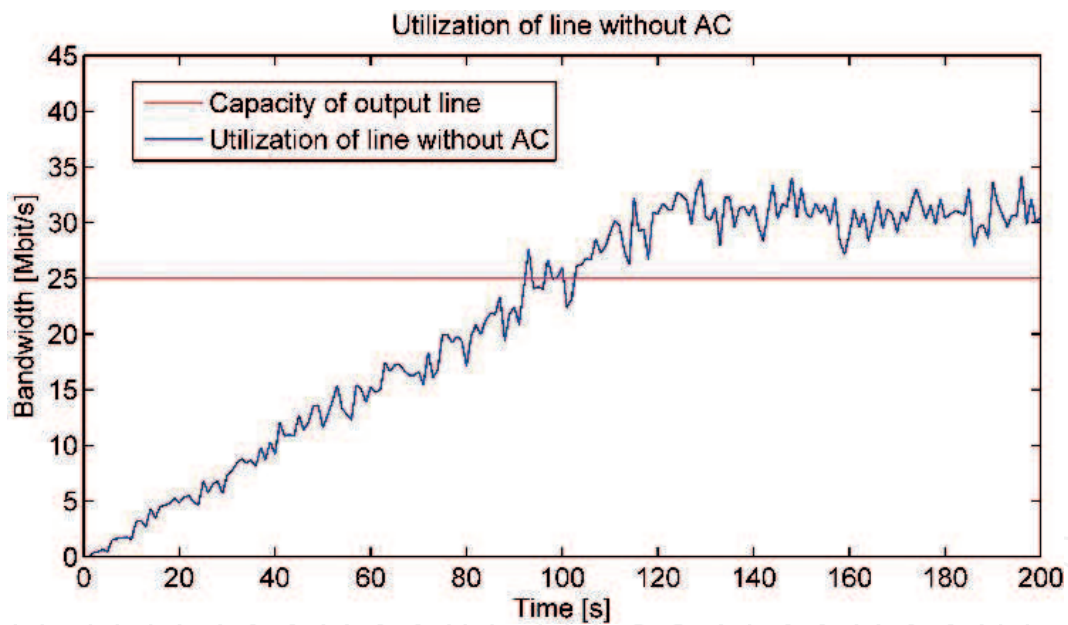


Figure 5. Expected utilization of line, when all sources are connected.

4.2.1. Measured sum

This method measures and sums bit rates of connected sources. The new connection is accepted or rejected due to the condition (3). **Figure 6** shows the accepted utilization of the line by the measured sum method.

It is obvious from **Figure 6** that when the method is applied, utilization of the line (green line) reaches the bound of the output capacity. The number of accepted connections is 90, which is the most of the compared simulated methods. The method maximizes utilization of the line

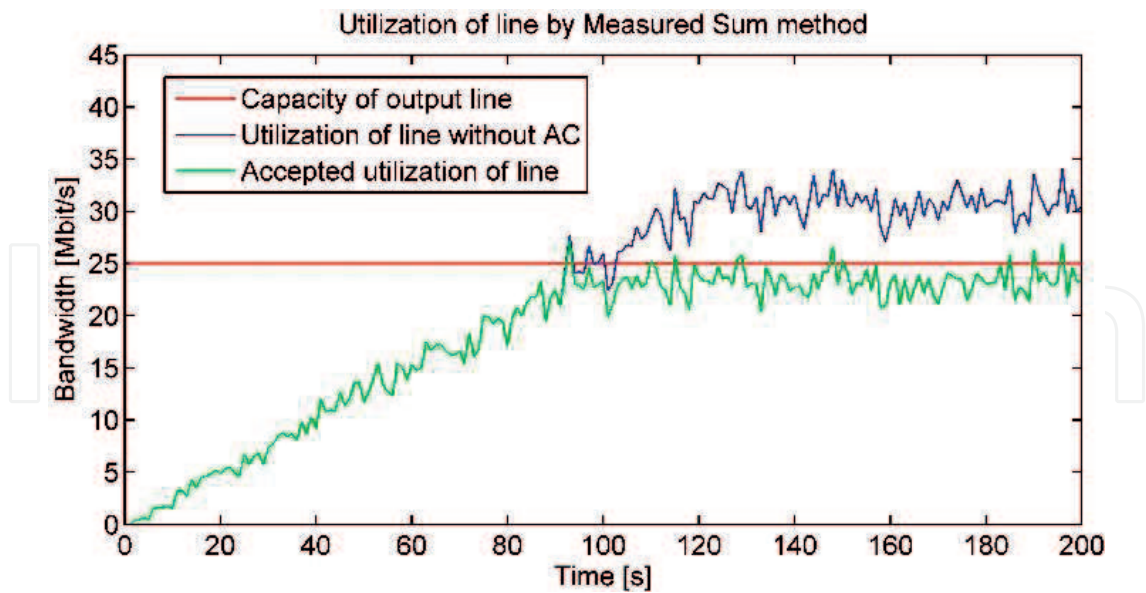


Figure 6. Accepted utilization of line by the measured sum method.

capacity. **Figure 6** shows that the output capacity can be overloaded in some points. The decision of the method depends on the immediate bit rates of the existing connections.

4.2.2. Peak rate allocation (PRA)

The new connection is accepted or rejected according to the condition (6). The accepted line utilization is shown in **Figure 7**.

In comparison with the measured sum method, the number of accepted connections is 46, which is half of the accepted connections by the measured sum method. PRA method is basically the

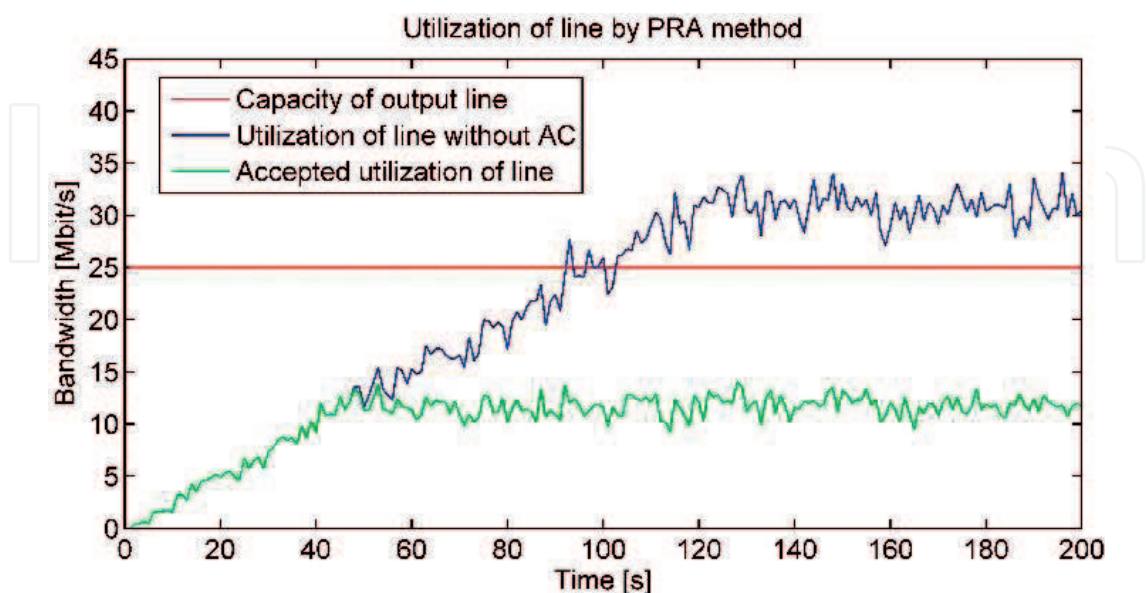


Figure 7. Accepted utilization of line by PRA method.

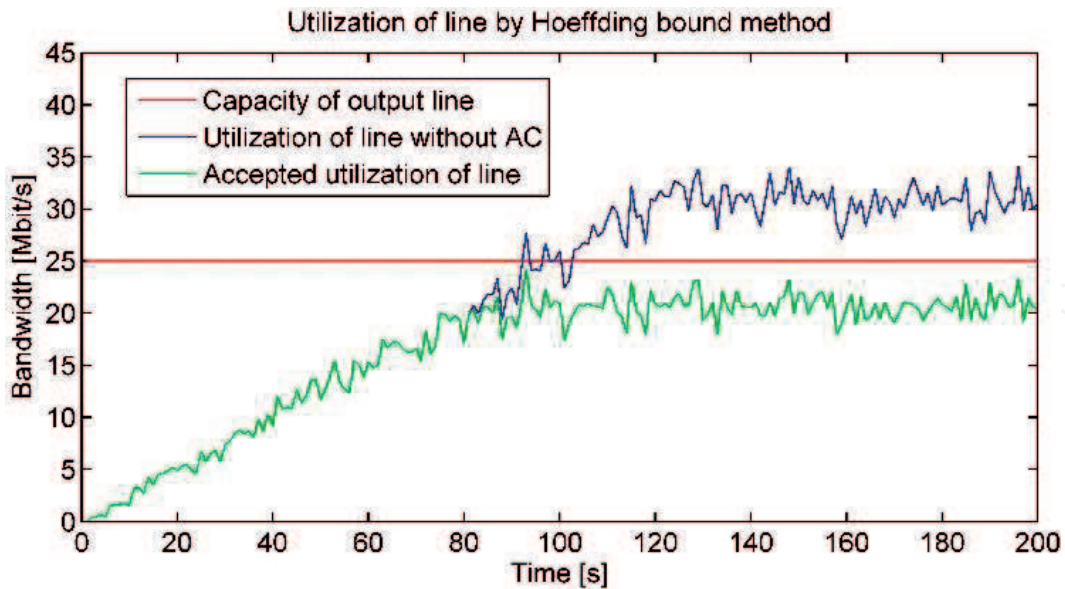


Figure 8. Accepted utilization of line by Hoeffding bound method.

opposite of the measured sum method [14]. It is caused by the fact that the PRA method allocates the capacity at the level of peak bit rate for every source. As we used VBR sources with randomly generated bit rates from the interval 0 to 512 kbit \cdot s⁻¹ with uniform distribution, the average bit rate is at the level of half of the peak bit rate. Due to this, the capacity of the output line is not utilized effectively. The method is more appropriate for the CBR traffic or for the traffic where the bit rates are close to the peak bit rates. On the other hand, QoS of the existing connections would be decreased rarely.

4.2.3. Hoeffding bound

The Hoeffding bound is computed according to Eq. (4). The decision-making about accepting or rejecting the new connection is made according to the condition (5). The accepted utilization of the line is shown in **Figure 8**.

The specification of the decision-making criterion depends on an appropriate width of the measured interval. An interval, which is too small can cause a nonobjective decision-making. If we include all samples, computational difficulty would be very high [14, 15]. Dynamical sliding of the measured interval solved this problem. The number of accepted connections is 80, which is more than PBAC and PRA methods, but less than the measured sum method [16].

Figure 8 shows that overload of the capacity was minimized. This method seems to be the most appropriate one from all of the simulated methods. It is kind of a compromise between the number of accepted connections and the capacity overload of the output line.

5. VBR method comparison

The accepted utilization of line by every VBR simulated method is shown in **Figure 9**.

Table 1 shows the number of accepted connections by every method.

From **Figure 9** and **Table 1**, it is obvious that the most accepted connections were achieved by the measured sum method. On the other hand, this method has the most overloads of the output line capacity. It would cause a decreasing QoS. The second highest number of accepted connections is Hoeffding bound method. The overload capacity is minimal. Thanks to that this method seems to be the most appropriate one. The least accepted connections achieved the PRA method. It seems to be the least appropriate one for this kind of traffic.

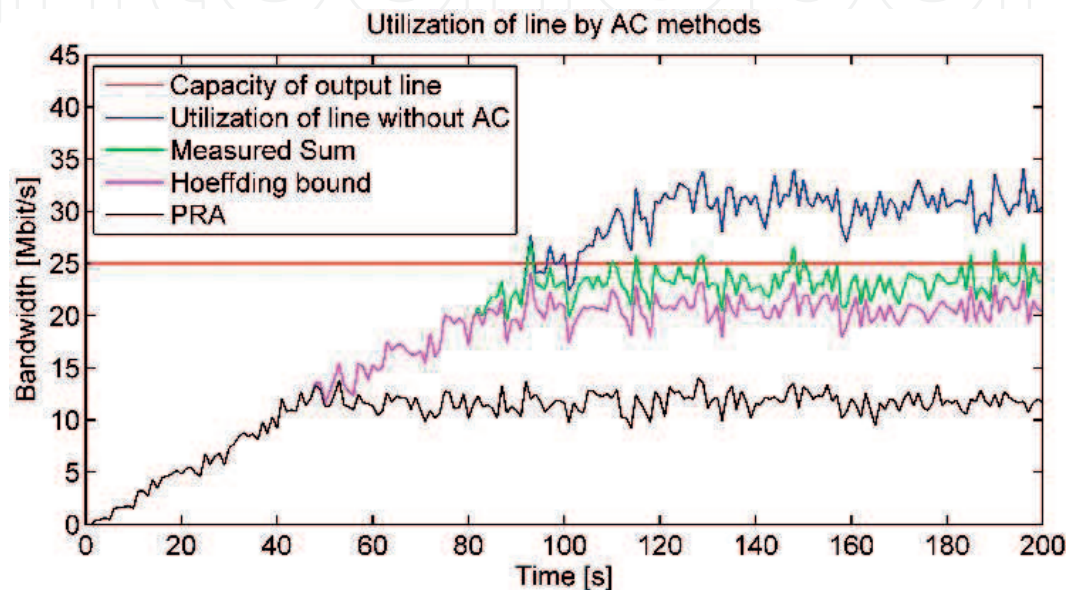


Figure 9. Accepted utilization of line by AC methods.

Method	Number of accepted connections
Measured sum	90
Hoeffding bound	80
PRA	46

Table 1. Number of accepted connections by every method.

6. Conclusion

Based on these results, we can claim that the AC methods are appropriate mechanisms for ensuring QoS in IMS networks. All known methods have the same function: to prevent overload and congestion. They have to decide whether the new connection will be accepted or rejected. From the simulations it is obvious that every method has advantages and disadvantages. The right choice of the method is very important for various specific kinds of traffic.

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